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What Do Pre-service Science Teachers Views about the Nature of Scientific Inquiry?

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Abstract

The nature of scientific inquiry is a concept associated with the nature of science and is an important product of inquiry-based teaching. Inquiry-based teaching is an important method proposed in science education all over the world. The aim of this study is to determine the pre-service science teacher's views about nature of scientific inquiry. As a data collection tool, The Views about Scientific Inquiry (VASI) questionnaire which developed by Lederman et al. (2014) was used. The questionnaire was translated in to Turkish by the researchers, and experts were assisted by their opinions and arrangements. The pilot data of the study were obtained with the participation of 56 pre-service teachers in the mathematics teacher program and 252 pre-service science teachers participate to get the main data. In addition, semi-structured interviews were conducted with 10 pre-service teachers. The results of the data variety are used to confirm the analysis of each other. In the analysis of the data, the participant's views are coded as uncategorized, naive, mixed, and informed. The results are presented as frequency and percentage. The data were evaluated by comparing with the pre-service teachers' grade levels. It was determined that the views of pre-service teachers about nature of scientific inquiry were not sufficient, but they were informed in terms of some aspects.

Keywords: Scientific Inquiry, Scientific Inquiry Questionnaire, VASI, Pre-Service Teachers

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INTRODUCTION

Nature of scientific inquiry (SI) has been a constant focus of science education over the past century and has become a trend all over the world. The United States, Britain, Japan, Taiwan, Turkey and many other countries, including what scientifically literate students-basic education reform (Abd-El-Khalick & Akerson, 2004; Ministry of National Education [MoNE], 2013, 2018; Li, Wang, Shen, et al, 2018) has become the main goal of science education. The understanding the nature of SI is an important concept for scientific literacy (Leblebicioğlu, Abik, Capkinoğlu et al, 2019; Şenler, 2014). It is also seen as an important method for individuals to take responsibility for the problems facing the world and for students to gain awareness in terms of sustainable development and is recommended by educators to use.

SI is a combination of traditional science content and critical thinking methods to enhance scientific process skills, creativity, and scientific knowledge (Lederman, 2009; Lederman et al, 2014). It is quite closely related to the nature of science (NOS). SI and the NOS are often used synonymously as well. The NOS embodies what makes science different from other disciplines, such as history and religion, and refers to how knowledge is developed and the characteristics of derived scientific knowledge (Lederman, 2006). However, SI can be expressed in the form of how scientists do their work and how the scientific knowledge obtained is produced and accepted (Mesci, Çavuş-Güngören, & Yeşildağ-Hasançebi, 2020). This distinction is also supported by the Next Generation Science Standards (NGSS), which distinguish between the NOS and scientific practices (Lederman et al, 2014). According to Lederman et al (2014), the nature of SI is seen as a difficult concept to define, as is the NOS. Pointing out that many definitions have been made in the literature, Lederman and his colleagues have identified eight characteristics related to the nature of SI. They stated that they saw these characteristics as knowledge that should be given to every student from pre-school education to higher education. These aspects are as follows: (1) scientific investigations all begin with a question and do not necessarily test a hypothesis; (2) there is no single set or sequence of steps followed in all investigations; (3) inquiry procedures are guided by the question asked; (4) all scientists performing the same procedures may not get the same results; (5) inquiry procedures can influence results; (6) research conclusions must be consistent with the data collected; (7) scientific data are not the same as scientific evidence; (8) explanations are developed from a combination of collected data and what is already known (Lederman et al., 2014).

SI refers to the characteristics of the processes by which scientific knowledge is developed, including scientific research and development, utilization, and utilization capabilities (Schwartz, 2004, p. 8). However, observation, review of what is known to see the books and other information resources; planning of experimental evidence, in light of what is already known review; data collection, analysis and interpretation for operating a vehicle; requires explanations and make predictions, and to share the results stages. At the same time, identification of assumptions requires critical and logical thinking and evaluation of alternative declarations (NRC, 1996, p.23).

Teaching based on inquiry offers a learning environment that allows knowledge to be investigated, learned, and evaluated by individuals (Perry & Richardson, 2001; Wu, & Krajcik, 2006). It is also necessary to create a learning environment in which students can create new thoughts, deepen their understanding, learn critical thinking, and experience different subjects. Individuals try to reveal the skills they have. In this process, we contribute to the development of our views on the NOS (Lederman, et al., 2014).

The use of inquiry-based teaching approach is suggested to educators in the science instructional programs renewed in Turkey, in 2013 and 2018 (Ministry of National Education [MoNE], 2013, 2018). In the program, " *... a holistic perspective is adopted in terms of teaching and learning theory and practice; in general, the student is responsible for his own learning, he has had active involvement in the learning process, and inquiry based learning strategy is based on the transfer of knowledge and on."* (MoNE, 2018). It is aimed to develop students ' sense of research and scientific thinking skills, to know science more closely, to understand the NOS, in short, to be equipped with the characteristics of the individual who is scientific literate. In order for the students to gain these characteristics, first of all, the competence of the teachers who will train them must be determined. This research is also important in terms of showing the degree to which pre-service science teachers (PSTs) possess this competence.

Inquiry-based education has been widely used in the Turkish science education context. Previous studies on the inquiry, the increase of studies on inquiry-based teaching draws attention (Ecevit & Kaptan, 2019; Kayacan & Selvi; 2017; Özgelen, Hacıeminoğlu & Yilmaz-Tüzün, 2007; Timur & Kincal, 2010; Sarı, Güven, Bakir Güven, 2013; Yilmaz & Karamustafaoğlu, 2015, Karamustafaoğlu & Celep Havuz, 2016). Researchers show that studies on inquiry-based learning are more focused on inquiry-based learning on specific topics (Kızılaslan, Sözbilir & Yaşar, 2012). This is caused by researchers investigating the effectiveness of the method in learning certain subjects (Kızılaslan, Sözbilir & Yaşar, 2012). However, there has not been enough work done on issues such as determining the level of inquiry views of individuals. The lack of sufficient research tools to determine the level of inquiry views is one of the reasons for the inadequacy in this regard. Kızılaslan et al (2012) conducted content analysis related to inquiry-based learning and teaching. In this context, they examined 40 works including 23 articles and 17 theses. It was determined that the studies were generally quantitative research and that the effect of inquiry-based teaching on learning was investigated (Şenler, 2014). In inquiry-based learning environments, what needs to be identified is to determine the participants ' inquiry skills or their characteristics related to the inquiry. This point also reveals the need for tools to identify these aspects.

Şaşmaz Ören and Sarı (2019) determined that the participant group in the study was mostly primary and secondary school students in which they examined the research based on the inquiry based on the strategy of science education on the Web of Science database. Considering that the nature of inquiry is important to form the basis of primary and secondary education level, the importance of the views of teachers and pre-service teachers who will give this basis becomes apparent (Karışan, Bilican, & Şenler, 2017). Accordingly, in this study, "what do PSTs views about the nature of SI?" research question was searched for answer. It is thought that this research will contribute to the current field literature in terms of comparing the views of pre-service teachers at different grade levels and providing information about the gains at each level.

METHOD

This study is a qualitative study that explores PSTs' views on the nature of SI. “Purposeful sampling”, the most common sample model used in qualitative research, was used to determine the study group. In the targeted sample model, in-depth information is collected about the person, event or situation that constitutes the subject of the research for a specific purpose. The use of this model is based on the acceptance that the study group selected in the research consists of people who the researcher believes will find answers to research problems (Sahin, 2009, p. 125). In this study, the group that will respond best to the research problem are PSTs. Therefore, total of 252 PSTs in the Faculty of Education were participated in this research. The data were collected in the 2015-2016 spring semester and the fall semester of 2016-2017.

Data Collection Tools

The Views about Scientific Inquiry (VASI)

“The Views about Scientific Inquiry (VASI)” questionnaire developed by Lederman et al (2014) was used as a data collection tool. The Turkish name of this questionnaire is stated by the researchers as “Bilimsel Sorgulama Hakkındaki Görüşler" (Appendix 1). The VASI questionnaire is the latest improved measurement tool for SI adapted from the views of Scientific Inquiry (VOSI) illuminated questionnaire that Schwartz, 2004, Schwartz and his colleagues developed in 2008. VOSI was developed to indicate the views of students, pre-service teachers, and scientists in inquiry. A measure of five open-ended questions on the five properties of the SI. However, Lederman et al (2014) found that at the end of many studies conducted with VOSI, not all characteristics for SI were adequately determined. At the end of this, with the new changes made on VOSI, the measure was reorganized as the VASI. The VASI contains seven contextualized open-ended questions, with new questions added to the VOSI. The following table (Table1) provides information on the matching of the items in the VASI and the aspects of the SI.

Table 1. The aspects of the SI and matching of VASI items (Lederman et al, 2014)

Characteristics of the nature of SI	VASI Article
1. All scientific research begins with a question, but does not necessarily need to be tested with a hypothesis	1a, 1b, 2
2. There is no single scientific method	1b, 1c
3. Scientists may not reach the same conclusions even if they follow the same procedures	3a
4. Inquiry processes may affect results obtained	3b
5. Scientific data and scientific evidence are different.	4
6. Questioning process, questions asked gives direction	5
7. Research results should be consistent with the data collected	6
8. Explanations are developed in the light of collected data and existing information (preliminary information)	7

Semi-structured Interview

Semi-structured interviews were conducted with the voluntary participation of 10 PSTs and using voice recording devices. Thus, deeper examination of individuals ' views was conducted. During the interview, participants were reminded of their answers and confirmed participants. The duration of the interview lasted between 20 and 30 minutes. The audio recordings were transcribed into written form and analyzed.

Research Process

The first step of the study of the adaptation of the VASI to Turkish started with obtaining permission for the use of it, then continued with the process of translating questionnaire into Turkish. English to Turkish language translation of the questionnaire was carried out by researchers with field knowledge and English proficiency and then re-examination of the translation was provided by two experts with field knowledge and English proficiency. As a result of the examination, the necessary technical corrections were made, and the questionnaire items were translated back into English by a native English expert to examine the consistency of the two forms in terms of language use and grammar. Thus, it was determined whether there was any difference in meaning between the two questionnaires. The final shape of the questionnaire was checked by the Turkish language expert.

A pilot application has been made to determine the failures experienced in the implementation of the questionnaire. For this purpose, the application was carried out with the participation of the pre-service teachers who were studying in the primary school mathematics education department, which was designated as the closest department to the science education program in the faculty of education. This application was reached to 56 pre-service teachers. The findings were analyzed. At this time, items that were particularly difficult to answer were examined (Çavuş Güngören, & Öztürk, 2016). In the light of the findings of the pilot data, the wording that causes printing error and low word or confusion of meaning was re-edited, and the final version of the questionnaire was given for the main research. 252 PSTs studying in different grade level have been reached. The distribution of the pre-service teachers views of each SI aspects into categories was determined. Semi-structured interviews were then conducted.

Data Analysis

VASI questionnaire it is stated that it can be evaluated as holistic way as VOSI scale. Participatory views on the aspects of SI are categorized as “unclear, naive, mixed and informed” by means of a holistic analysis. Accordingly, the answers that individuals have given to questions, such as the view categories specified, are coded as “unclear,” “naive,” “mixed,” and “informed.” The steps related to coding the questionnaire are in parallel with the study of Lederman et al (2014), and the guidelines in question were followed when placing participant views into these categories.

For example, informed coded views understood this aspect and were observed to consistently reflect this understanding in other questions as well. The answers in the mixed category were found to have ideas that could be considered naive in other questions as well as expressing that they understood the current property. Answers in the naïve category are those that contradict or do not conform to accepted views on the nature of the inquiry. The unclear category is used for answers that have no relation to the nature of the inquiry being examined. At the end of the coding, the codes for all participants were summarized in a table, the distribution of the categories was determined by frequency and percentages, and the difference between the views of the participants at different grade levels was interpreted.

The results of the data variety are used to confirm the analysis of each other. Researchers (Cresswell, 2007; Merriam, 2013) made suggestions in this direction. The analyses were carried out together with all the researchers. In order to make the analyses consistent, analysis forms and forms in similar research have been examined and accordingly, analysis forms appropriate to the research have been created. In line with these forms, the findings were reviewed multiple times, with attention being paid to the consistency of the findings obtained within themselves and from different data sources. Therefore, the results of the questionnaire and interview transcripts were obtained.

To ensure validity and reliability, Miles and Huberman (1994) researchers on the same data sets they create, and the resulting code could be obtained numerically by comparing the similarities and differences between the encodings stated that a coding percentage. They emphasized that it is important to achieve a reliability percentage of at least 70%. The formula “Agreement/(Agreement + Disagreement) x 100” was used to calculate this percentage (Miles, &Huberman, 1994) and calculated 96% consensus.

FINDINGS

In this study "What do PSTs think about the nature of SI?" and “What is the level of knowledge of PSTs about the characteristics of SI?” questions have been answered. The sample statements of the PSTs, which are coded as informed and naive (inadequate views) towards the nature of SI and its characteristics, are included in Table 2. The answers that are excluded from these encodings are encoded as mixed (complex views).

Table 2. Sample participatory statements categorized as knowledgeable and naive towards the eight characteristics of SI

SI aspects (Question number)	Informed	Naive
1.All scientific research begins with a question, but does not necessarily need to be tested with a hypothesis (1a, 1b, 2)	"Yes, it starts with a question. If you start with a scientific question, the idea becomes clear and the subject of research becomes clear and clear. For example, if the student is asked about the effect of light color on the development of the plant, the student will focus only on the color of light and conduct research on it. But if asked what affects the development of the plant,	"No, sometimes scientific research begins without question.” (K4b-14)

	different research issues arise." (K4b-29)	
2. There is no single set or sequence of steps followed in all investigations (1b, 1c)	"More than one method can be traced in scientific research. Can do both quantitative and qualitative research. Numerical data can be obtained by quantitative research. With qualitative research, face-to-face interviews can also be conducted to collect data." (K4a-6)	"No. Scientific research should be a single method and its stages should be done as a standard." (K3b-12)
3. All scientists performing the same procedures may not get the same results (3a)	Even if scientists investigate the same question and follow the same methods, they come to different conclusions. Because their preliminary knowledge is different from the social environment in which they live and their culture, they reach different conclusions. (K4a-13)	It's reaching the same conclusions. This is because he's investigating the same question and following the same methods. (K3b-6)
4. Inquiry processes can influence results (3d)	Even if scientists investigate the same question, pursuing different methods of collecting data can lead them to different data and make them different in their results. (K4a-7)	Yes. The method is different, but the result is late. Rough data is collected, but the result is the same. Like the elevator and stairs in the building 5. He goes up to the floor in the elevator and up the stairs. (K3b-19) Because scientific knowledge is universal, the result will be one and the same, although different methods may be followed. (K3a-29)
5. Scientific data are not the same as scientific evidence (4)	Data and evidence are different. Data the information we obtain in our study is our evidence to interpret them. (K3b-12)	I think there's no difference. Because every data is an evidence, every evidence is a data. (4b-7)
6. Inquiry procedures are guided by the question asked (5)	I think the A-team's path is better. Because they have followed a path that is of the same nature as the question asked. In short, it is relevant to the question, hence the purpose. (K4a-4)	The path followed by team B makes more sense. It is understood that a single brand that is tried is better in which other roads and which one is worse. (K3b-9)
7.Research conclusions must be consistent with the data collected (6)	Plants grow taller with less sunlight. When we look at the data in the table, we see a decrease in the growth of the plant as the sunlight increases. (K4a-7)	Plants need sunlight to grow. (K2b-4)
8. Explanations are developed from a combination of collected data and what is already known (7)	Prior knowledge of the social and cultural lives of scientists is very important. They use the background information about dinosaurs, they do research, they follow a path based on evidence and data, and they explain accordingly. (K4b-22)	It could have moved according to the mass of the dinosaurs and arranged the bones that way. (K4b-11)

The study compared the views of the PSTs at different grade levels and examined the levels of knowledge about the attainment at each grade. Accordingly, the findings of the distribution of PSTs' views on the nature of SI by categories and grade levels are presented in Table 3.

Table 3. Percentage and frequency values of PSTs classified as having naive, mixed, and informed views with eight aspects of SI

Participants %	All scientific research begins with a question, but does not necessarily need to be tested with a hypothesis					There Is No Single Set or Sequence of Steps Followed in All Investigations					All Scientists Performing the Same Procedures May Not Get the Same Results					Inquiry processes can influence results				
Grade	1	2	3	4	Total (%)	1	2	3	4	Total (%)	1	2	3	4	Total (%)	1	2	3	4	Total (%)
Unclear	0	1	1	1	1	5	6	8	8	7	0	1	0	3	1	3	4	5	5	4
Naive	69	71	51	67	65	90	57	38	21	51	33	33	31	8	27	22	21	23	11	19
Mixed	29	21	38	30	29	5	29	49	46	33	21	39	20	13	24	62	46	16	15	35
Informed	2	7	10	1	5	0	8	5	25	9	47	26	49	75	48	12	29	56	69	41
N	58	72	61	61	252	58	72	61	61	252	58	72	61	61	252	58	72	61	61	252

	Scientific data are not the same as scientific evidence					Inquiry Procedures Are Guided by the Question Asked					Research Conclusions Must Be Consistent with the Data Collected					Explanations Are Developed from a Combination of Collected Data and What Is Already Known				
Grade	1	2	3	4	Total (%)	1	2	3	4	Total (%)	1	2	3	4	Total (%)	1	2	3	4	Total (%)
Unclear	0	3	1	3	2	2	7	6	8	6	2	1	3	3	2	2	1	1	1	2
Naive	2	32	77	67	44	29	18	15	10	18	47	15	23	10	23	62	47	64	34	52
Mixed	93	62	21	30	52	17	15	0	0	8	8	14	21	18	15	15	38	23	56	33
Informed	5	3	0	0	2	52	60	79	50	68	43	69	52	69	59	21	14	11	8	13
N	58	72	61	61	252	58	72	61	61	252	58	72	61	61	252	58	72	61	61	252

Table 3 shows the percentage and frequency values of PSTs classified as having unclear, naive, mixed, and informed views in eight aspects of SI. To be more descriptive and comprehensible, the data obtained is presented below by converting it into a graphical form.

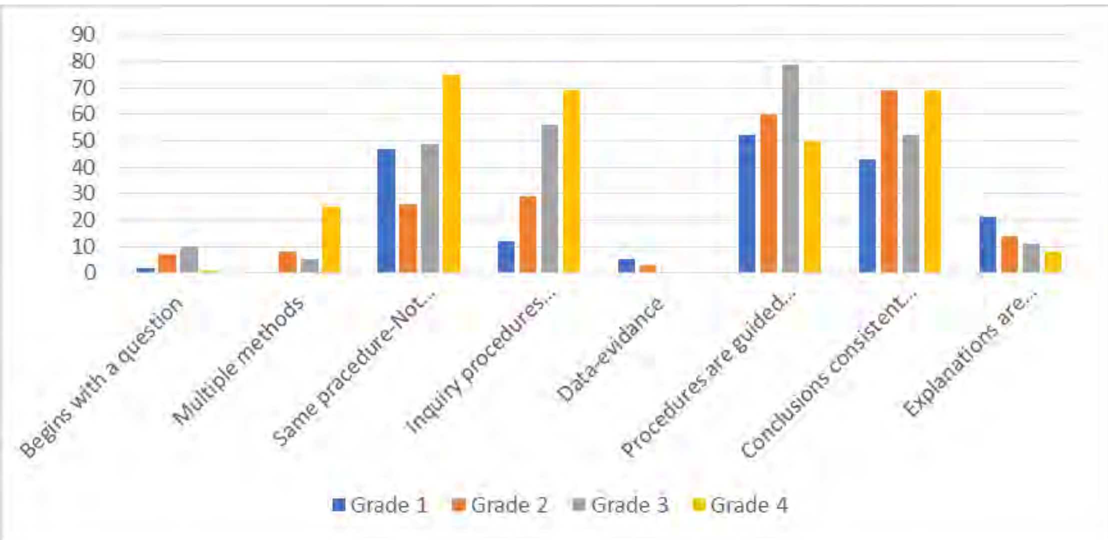

Figure 1. "Informed" percentages of distribution according to grade levels

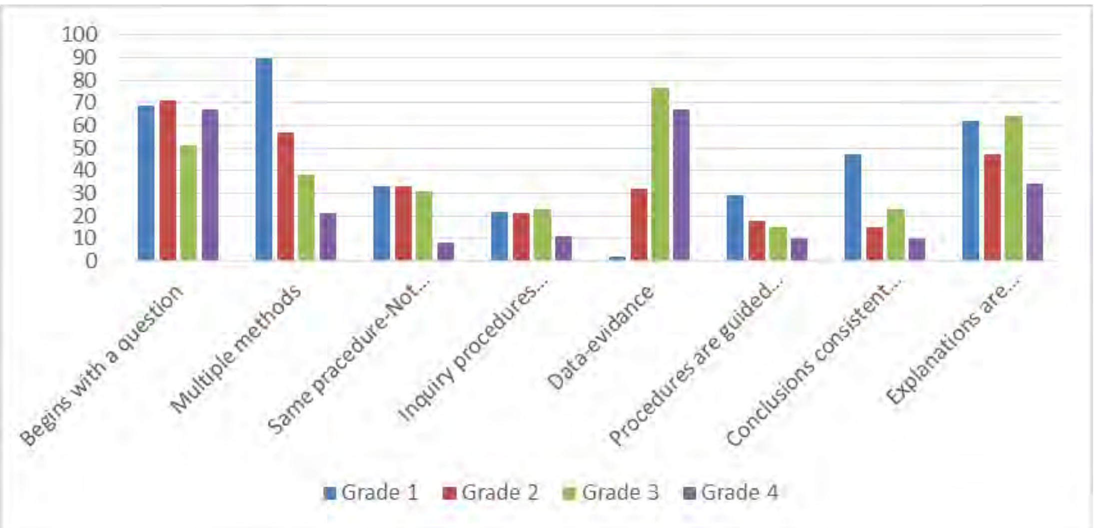

Figure 2. "Naive" percentages of distribution according to grade levels

Figure 1 shows the percentage trend of PSTs classified as having informed views on eight aspects of SI, while Figure 2 shows the characteristics found at naïve (insufficient) levels in graphic form. Further examination shows that PSTs are more informed in three aspects of SI- even if scientists follow the same procedures, they may not reach the same conclusions; questions lead to the inquiry process, research results should be consistent with the data collected. On the other hand, it is understood that the PSTs have insufficient views in terms of other characteristics of SI. It was determined that the difference between the data and the evidence facts could not be made. The inadequacy of this trait is quite remarkable.

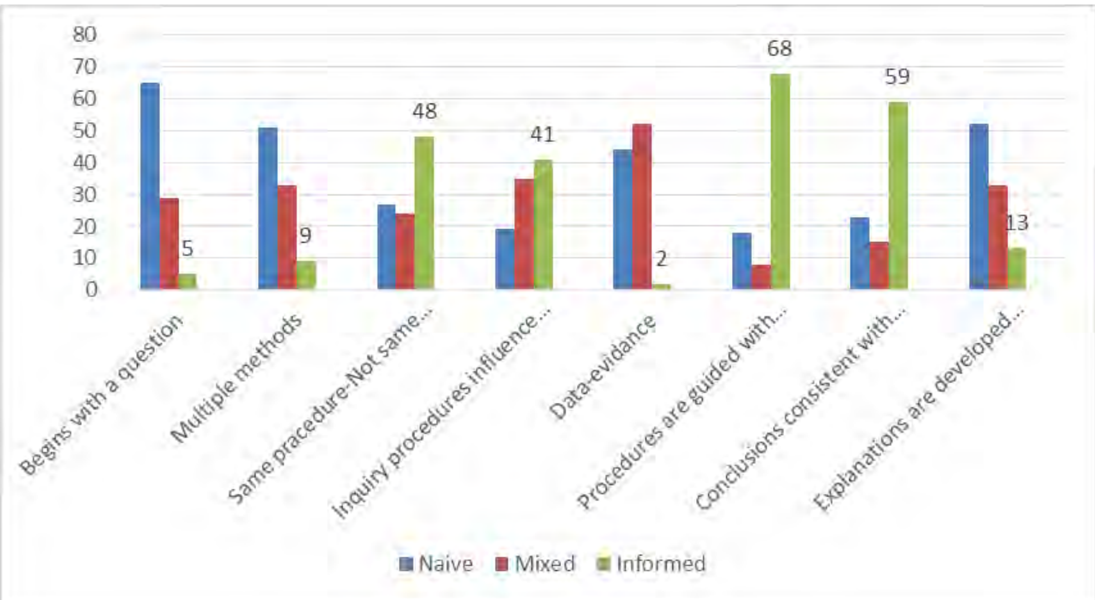

Figure 3. Total percentage distributions of PSTs according to eight characteristics of SI

Figure 3 shows the naïve, mixed, and informed levels of PSTs according to eight characteristics of SI in total for all grade levels. The results of each inquiry aspects are examined individually, and the views and levels of the PSTs are given below.

All scientific Research Begins with A Question, But Does Not Necessarily Need to be Tested with A Hypothesis

It was determined that 65% of PSTs had a naive view about this aspect. The participants gave naive, i.e. insufficient, answers to start scientific research with a single question. Naïve views were observed in sophomores of the most naïve views when compared in terms of grade level. It was followed by freshmen, seniors, and juniors.

"When I say scientific question, I think there should be a problem in this problem that may not be close to scientific. So, it may not actually be scientific. (Ece.) " It has been established that a participant has a naive view of starting scientific research with questions.

It was determined that 29% of the participants had a mixed view, while only 5% had informed view. Although it is observed that the PSTs with informed view belong to juniors at most, this ratio is 10% of the class itself. That is a low rate.

There is no Single Set or Sequence of Steps Followed in All Investigations

It was determined that 51% of PSTs had a naive view about the lack of a single scientific method of SI. It was determined that most freshmen were of naive view, with a ratio of 90% on this subject by grade level. The percentage of naive views has been found to tend to decrease as grade level increases.

It was observed that 33% of PSTs had a mixed view, while 49% of junior PSTs had the most mixed view-appropriate responses. It was observed that only 9% of all participants were of informed view. In contrast to naive views, informed views tend to increase as the grade level increases. According to this, 25% of senior pre-service teachers were found to express view in accordance with the informed category.

"Yes, they can use their pre-knowledge of rational explanations, their observations of the imagination where they are put forth by experiments. Many methods can be used, not one method. Because it is of nature origin, it can be revealed by observing and researching theories." (Aysel)

All Scientists Performing the Same Procedures may not Get the Same Results

The naïve views on the property that different conclusions can be reached even if the same procedures are performed by scientists vary between 8% and 33% according to grade level. Naïve views of the entire participating group were 27% and mixed views were 24%. It was observed that 48% of participants gave answers in accordance with informed view. Seniors gave answers with 75% having the most informed views, while 49% of juniors and 47% of freshmen gave answers in accordance with the informed views. 26 percentages of sophomore pre-service teachers gave answers in informed view. Observations, culture, imagination, and creativity, such as different reasons to achieve different results have been expressed as factors. When the participants' statements are examined, the responses to the relevant question support this finding. For example:

"They may not all reach the same conclusions. Because both scientists can make separate observations. You know, the observation results might be different. His thoughts may be different. So, I think it's different. They don't reach exactly the same results, but they can reach similar results."(İpek)

"They may not all reach the same conclusion. Everyone has their own cultural life. He has religious views. They are also very influenced by imagination and creativity. I don't think you'll get the same result for that. Even if they use the same methods, human life is also very important. Imagination, where it can reach, it matters. Structure of thought is very important in important circumstances."(Ece)

Inquiry Processes may Affect Results Obtained

It was determined that 19% of participants were naive, 35% mixed, and 41% informed about the effect of the inquiry processes on the results obtained. The grade-level distribution of naive views is between 11% and 22%, and they appear to be close together. When the distribution of mixed view is examined, it is observed that the highest number of freshmen PSTs are coded with 65%. The mixed view percentage in sophomores are 46%. The mixed view percentage in junior and senior pre-service teachers are 16% and 15%. On the other hand, informed views increased as grade levels increased. More than half of junior and senior PSTs believe that the process of SI affects the results achieved at the end of the process. It can be said that a participant who expresses his view *"We can do scientific research in many ways. For example, we can make observations or do controlled experiments* *according to our purpose. Whatever path we chose, this inquiry will ultimately affect our results. (Sevgi)"* has an informed view that the inquiry processes will affect the results obtained.

Scientific Data are not the Same as Scientific Evidence

It is observed that 44% of teachers have a naive view about the difference between scientific data and evidence. When examined on grade level, 77% of juniors, 67% of seniors, 32% of sophomores, and 2% of freshmen coded in naive view. In addition, some of the interviews stated that they could not distinguish between data and evidence:

"In my opinion there is not much difference. Data, I think, is information collected because of observations made about a subject, research. The evidence is a subject, a concept used to make the conclusions collected about it conclusive. (Burcu)". "I think both data and evidence are the same thing. I think of it as information presented to prove the truth of a problem or problem. (Sinem)

The 52% of participants were determined to have a mixed view, while only 2% coded in informed view. The most pre-service teachers with mixed views are freshmen pre-service teachers. Most participants with informed view are still freshmen. None of the juniors and seniors expressed any informed view. This is thought to be quite remarkable.

Inquiry Procedures are Guided by the Question Asked

When Table 3 was examined, it was observed that PSTs informed view ($\sum f=171$, N=252) about this aspect ant it was between 30% and 50% according to grade level. The percentage of naive views on this aspect of SI varies between 10% and 29% according to grade level. It was observed that 68% of participants gave answers in accordance with informed view. This can be said to be the highest rate in terms of all inquiry characteristics. With 79% of juniors giving answers with the most informed view, 60% of sophomores and 52% of freshmen gave answers in accordance with the informed category. The seniors, 50% gave answers in informed view. When the participants' statements are examined, the responses to the relevant question support this finding. For example:

"The problem situations put forth in the first-place lead to the interrogation process because we get the right answers with the right questions for the intended purposes." (İnci)

Research Results should be Consistent with the Data Collected

The PSTs who participated in the study were also "more informed ($\sum f=139$, N=252)" in terms of the dimensions of the data collected during the inquiry process to be consistent and compatible with the results. It was observed that 68% of participants gave answers in accordance with informed view.

This can be said to be the highest rate in terms of all inquiry characteristics. For example, one of the PSTs who participated in the research said, *"scientific research should of course provide results that are consistent with the collected data. Otherwise, we can't talk about the success and reliability of the work."(Esra)* expressed her informed view on this issue. Similar statements were obtained from other PSTs whose transcripts were obtained. A non-routine table on plant growth was given in the question intended to reveal this aspect in the measurement tool and PSTs were asked to interpret it. *"When I look at the table every day, when the minute of light received increases, the growth of the plant decreases in inches. Therefore, plants grow more with less sunlight, I think " (Kübra)* commented that the data collected in accordance with the results again informed view.

Sophomores and seniors gave answers with 69% of their own with the most informed view, while 43% of freshmen and 52% of juniors fit into the informed category (see Table 3) they gave answers. Seniors, 50% gave answers in informed views. In this case, it is seen that informed view prevails at all grade levels.

Explanations are Developed from a Combination of Collected Data and What is already Known

The development of scientific explanations in the light of the data shows that PSTs have a naive view. It was determined that 52% of PSTs had a naive view about this aspect of SI. In other words, the participants gave naïve or inadequate views to the development of scientific explanations in the light of the data and foreknowledge collected. Naïve views were observed in juniors (64%) with the most naïve views compared in terms of grade level. It was followed by freshmen (62%), sophomores (47%) and seniors (34%).

Conspicuous in the way that supports this situation, a sample participant can *"advance knowledge and scientific explanation can also be developed without previously obtained knowledge. We don't need to know much about the subject to find something new. (Gamze)* " in the form of his view of starting scientific research with questions shows that he has a naive view. A total of 33% of participants had a mixed view, while only 13% gave answers suitable for coding in informed view.

In addition to the above-mentioned findings, when the distribution of PSTs into inquiry categories in terms of grade levels is examined, it is observed that their knowledge increases according to glade level in terms of "directing questions to the inquiry process", "achieving different results even if the same procedures are applied", and "consistent results of the data collected during the inquiry process". While there was a mixed view about the "inquiry processes affecting the results" of freshmen and sophomore PSTs. There was an increase in this information when it came to the junior and senior pre-service teachers. In this case, it is thought that courses such as scientific research and the NOS taken by PSTs in the third grade of the undergraduate program are effective.

CONCLUSION AND DISCUSSION

It is of great importance for teachers to understand SI well, to be able to convey it correctly to students and to grow up to be science literate because inquiry-based learning is proposed and included in many teaching programs worldwide today (NRC, 2011; MoNE, 2013, 2018). At this point, the views, knowledge, and competence of teachers about SI have gained an unquestionably importance in the current programs in which contemporary educational understanding has been adopted. Science, in terms of its interdisciplinary content, is the most prominent discipline in an educational environment created for SI. Therefore, with this importance in mind, the views of PSTs who have not yet started these processes were measured by this study. As a matter of fact, when studies on inquiry skills and inquiry-based teaching are examined, the quantitative scarcity of research conducted especially at the undergraduate level in our country is noted. In their content analysis study, Ören and Sarı (2019) noted the scarcity of studies in this regard in recent years and stated that the participants were mostly primary and secondary students. At this point, as in this research, it is thought that the quality and quantity of the studies on PSTs will increase and become a guide in the field.

According to the results of the research, it was determined that the views of PSTs about SI were not sufficient. However, some of the PSTs can be said to be informed in terms of some inquiry aspects. It was determined that the group was informed in terms of "guidance of questions to inquiry procedures", that "even if the same procedures are applied, different conclusions can be reached", and that "research conclusions must be consistent with the data collected". In addition, it is observed that their knowledge in these dimensions increases according to glade level. This result coincides with another study (Celep Havuz & Karamustafaoğlu, 2016) conducted with pre-service teachers in our country, Turkey. The study concluded that each grade level of PSTs from first to fourth grade had a significant difference in favor of the upper grades in their perceptions of inquiry-based learning relative to their lower grade levels. However, other aspects of SI such as “all scientific research starts with a single question”, “there is no single set or sequence of steps followed in all investigations”, “scientific data are not the same as scientific evidence” and “explanations are developed from a combination of collected data and what is already known” are seen to have naive views of the PSTs. That is, PSTs can be said to be inadequate in these dimensions. This result also coincides with the study of Gaigher et al (2014).

The results of the “lack of a single scientific method” aspect was quite remarkable, especially in SI. There were no informed views from the seniors, while only 5 and 8 students from the sophomores and juniors, respectively, provided informed views. PSTs come to their undergraduate education by taking many science-related courses in their primary and secondary education. While their knowledge of the scientific method was expected to increase in these courses, they were found to be severely inadequate in this study. In this case, it is thought that more gains and activities should be included in the programs to develop knowledge and skills related to the scientific method. Because it is known that it is important to lay the foundation of the opportunities offered to students in primary and secondary education. According to Kelley and Knowles (2016), inquiry-based learning prepares students to think and act like scientists, ask questions, hypothesize, and conduct research using standard science practices. Therefore, it can be said that it is important to establish a foundation at primary and secondary education level.

In the course of the study, there was a mixed view about the “impact of the inquiry processes” freshmen and sophomore the PSTs, while there was an increase in their views of this particular issue at the juniors and seniors. In this case, it is thought that courses such as scientific research and the NOS taken by pre-service teachers in the second year of their undergraduate program are effective. Again, it was concluded that PSTs could not distinguish between data and evidence, which is one of the important aspects of SI. It was determined that a certain percentage of PSTs had a mixed view on this issue.

It is necessary to encourage teachers to use SI training and teaching as a tool to help students better understand scientific concepts and procedures (Minner et al, 2010). In the light of all the data in this study, it can be said that PSTs' views on SI are not enough informed. In other words, the PSTs in the study group do not have adequate SI views. Karışan, Bilican, and Şenler (2017) stated that preservice teachers usually have transformative views with none of them holding naïve views regarding SI. It is thought that PSTs should develop the ability to conduct SI because even graduates who are ready for the profession have a low level of ability to make SI, it shows that they will be extremely inadequate in planning and carrying out inquiry-based instruction in their classrooms in the future. As a matter of fact, it is thought that this deficiency will negatively affect the development of the targeted scientific skills in the next generation.

As reported by Kızılaslan et al (2012), the content analysis of inquiry-based learning and teaching found that most of the studies based on inquiry-based teaching were quantitative and focused on the impact of inquiry-based teaching on learning (Şenler, 2014). However, as Lederman et al (2014) noted, inquiry skills have depth that cannot be determined only by quantitative methods, and data must be collected by qualitative means to have more detailed information. At this point, it was thought that an in-depth examination of SI skills was needed at the national level while this study was being planned. When we look at the relevant national literature, it is thought that the existence of a qualitative data collection tool is needed in order to make a more in-depth examination, contributing to the fact that the three scales (Taşkoyan, 2007; Karademir, 2013; Şenler, 2014) which are prepared for the determination of SI are quantitative tools. As a matter of fact, according to the results obtained from the questionnaire adapted in this study, the lack of SI skills of PSTs leads to the need for more qualified studies on SI skills and development.

Recommendations

PSTs' views on nature of SI were examined in this study. In the light of the data obtained, it was observed that PSTs did not have sufficient view and knowledge on SI. For this reason, it is thought that it is necessary to investigate how the inquiry skills of teachers and students develop over time. Research should be carried out on how knowledge about inquiry develops in classrooms. It is known that individuals' scientific process skills began to develop from a fairly young age. In this case, it is thought that the investigations related to SI should cover both the pre-school period and the primary, middle, and upper levels of education. At the same time, the impact of different teaching strategies and methods on SI should be examined. This examination can be carried out with students at all levels of education, as well as before service for teachers.

This study is an investigation into the existing SI skills of PSTs. However, is it sufficient to have the skill of inquiry to teach it? The answer to this question can be investigated in the continuation of this descriptive study and in-service training studies can be planned. Finally, the relationship of SI with other disciplines can be explored because science education requires the development of science as well as other branches of science.

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REFERENCES

Abd-El-Khalick & Akerson (2004). Learning as conceptual change: Factors mediating the development of preservice elementary teachers' views of nature of science. *Science Education.* 88 (5), 785-810.

American Association for the Advancement of Science [AAAS]. (1993). Benchmarks for science literacy: A project 2061 report. New York: Oxford University Press.

Aldan Karademir, Ç. (2013). *Öğretmen adaylarının sorgulama ve eleştirel düşünme becerilerinin öğretmen öz yeterlik düzeyine etkisi*. Yayınlanmamış Doktora Tezi, Adnan Menderes Üniversitesi, Sosyal Bilimler Enstitüsü: Aydın.

Balım, A. G., & Taşkoyan, N.(2007). Fene yönelik sorgulayıcı öğrenme becerileri algısı ölçeğinin geliştirilmesi. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi*, *21,* 58-63.

Cresswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five traditions* (2nd ed.). California: Sage.

Cresswell, J.W. (2012). *Educational research: planning, conducting, and evaluating quantitative and qualitative research* (4th edition), Boston: Pearson.

Çavuş Güngören S., & Öztürk E.(2016). *Turkish adaptation of the views about scientific inquiry VASI and examine pre-service mathematics teachers views about scientific inquiry.* VI. International Congress on Research in Education (ICRE).

Ecevit, T. & Kaptan, F. (2019). Fen öğretmen adaylarının argümantasyon destekli araştırma-sorgulamaya dayalı öğretim yeterliliklerin geliştirilmesi. *Elementary Education Online,* 18(4), 2041-2062. Available at: <http://ilkogretim-online.org.tr/index.php/io/article/view/3343/2664>. Date accessed: 06 feb. 2020.

Gaigher, E., Lederman N, Lederman J. (2014). Knowledge about Inquiry: A Study in South African High Schools. International Journal of Science Education. 36(18), 3125-3147.

İnaltekin, T. & Akçay, H. (2012). *Fen ve teknoloji öğretmenliği adaylarının sorgulamaya dayalı fen öğretimi öz-yeterliliklerinin incelenmesi.* X. Ulusal Fen ve Matematik Kongresi, Niğde üniversitesi, Niğde, 27-30 Haziran 2012.

Kaleli Yılmaz, G. (2014). Durum çalışması. Mustafa Tekin (Ed.), *Eğitimde bilimsel araştırma yöntemleri* içinde (s. 261-285). Ankara: Pegem.

Karamustafaoğu, S., & Celep Havuz, A. (2016). Inquiry based learning and its effectiveness. *International Journal of Assessment Tools in Education, 3,* (1), 40-54.

Karışan, D., Bilican, K., & Şenler, B. (2017). The adaptation of the views about scientific inquiry questionnaire: a validity and reliability study, *Inonu University Journal of the Faculty of Education*, *18*(1), 326-343. DOI: 10.17679/inuefd.307053

Kayacan, K., & Selvi, M. (2017). Öz Düzenleme faaliyetleri ile zenginleştirilmiş araştırma-sorgulamaya dayalı öğretim stratejisinin kavramsal anlamaya ve akademik öz yeterliğe etkisi. *Kastamonu Eğitim Dergisi, 25 (5), 1771-1786.* Retrieved from https://dergipark.org.tr/en/pub/kefdergi/issue/31226/342736

Kelley, T. R. & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3(1), 11. DOI 10.1186/s40594-016-0046-z

Kızılaslan, A., Sözbilir, M., & Yaşar, M. D. (2012). Inquiry based teaching in Turkey: A content analysis of research reports. *International Journal of Environmental & Science Education, 7*(4), 599-617.

Leblebicioglu, G., Abik, N.M., Capkinoglu, E. *et al.* (2019). Science camps for introducing nature of scientific ınquiry through student ınquiries in nature: two applications with retention study. *Res Sci Educ,* 49, 1231–1255. https://doi.org/10.1007/s11165-017-9652-0

Lederman, J.S., Lederman, N.G. Bartos, S.A. Bartels, S.L. Meyer, A.A. & Schwartz R.S. (2014). Meaningful assessment of learners' understandings about scientific inquiry—The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching, 51* (1), 65–83 http://dx.doi.org/10.1002/tea.21125

Lederman, N. G. (2006). Research on Nature of Science: Reflections on the Past, Anticipations on the Future. Asia-Pasific Forum on Science Learning and Teaching. 7 (1).

Li, X. Y., Wang, L. S., Shen, J. L., Wang, J. Y., Hu, W. P., Chen, Y. H., & Tian, R. H. (2018). Analysis and comparison of scientific inquiry activities in eighth-grade physics textbooks in China. *Journal of Baltic Science Education*, 17(2), 229–238.

Merriam, S. B. (2009). *Qualitative research. A guide to design and implementation*. San Francisco: Jossey-Bass.

Merriam, S. B. (2013). *Nitel araştırma. Desen ve uygulama için bir rehber.* (S. Turan. Çev.). Ankara: Nobel.

Mesci, G., Çavuş-Güngören, S., & Yesildag-Hasancebi, F. (2020) Investigating the development of pre-service science teachers' NOSI views and related teaching practices, *International Journal of Science Education*, 42(1), 50-69, DOI:10.1080/09500693.2019.1700316

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*. CA: Sage.

Minner, D, Levy, A & Century J, (2010). Inquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Science Teaching,* 47(4), 474-496.

Ministry of National Education [MoNE]. (2013/2018). İlköğretim kurumları fen bilimleri dersi öğretim programı [Primary education institutions' science instruction program]. Ankara: Talim Terbiye Kurulu Başkanlığı.

National Research Council [NRC]. (2011). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

National Research Council. (1996). *National science education standards. Washington*. DC: National Academic Press.

National Research Council. (2000). *Inquiry and the national science education standards*. Washington, DC: National Academy Press.

Özgelen, S., Hacıeminoğlu, E., & Yılmaz-Tüzün, Ö. (2007, August). *Investigation the effect of inquiry method on developing prospective teachers' science Turkish adaptation of the competence scale for learning science: process skills through word association test.* Paper presented at the European Science Education Research Association (ESERA), Malmö, Sweden.

Perry, V. R., & Richardson, C. P. (2001). The New Mexico Tech Master of Science Teaching Program: An Exemplary Model of Inquiry-Based Learning. *31 st ASEE/IEEE Frontiers in Education Conference.*

Şahin, B. (2009). Metodoloji, bilimsel araştırma yöntemleri. A. Tanrıöğen (Editör), *Bilimsel Araştırma Yöntemleri*, Ankara: Anı.

Sarı, U., Güven, G. & Bakır Güven, G. (2013). Etkileşimli tahta destekli sorgulamaya dayalı fizik öğretiminin başarı ve motivasyona etkisi ve öğretmen adaylarının öğretime yönelik görüşleri. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi*, 7 (2), 110-143 . DOI: 10.12973/nefmed204

Şaşmaz Ören, F., & Sarı, K. (2019). 'Web of science' veri tabanında fen eğitimi üzerine yapılan araştırmaya dayalı öğrenme stratejisi konulu çalışmaların değerlendirilmesi. *Elementary Education Online,18(*4), 1875-1901.

Schwartz, R.S., Lederman, N.G. & Lederman, J.S. (2008). *An instrument to assess views of scientific ınquiry: The VOSI questionnaire.* Annual Meeting Of The National Association For Research In Science Teaching, Baltimore, MD.

Şenler, B. (2014). Turkish adaptation of the competence scale for learning science: validity and reliability study [Fen Öğrenme Becerisi Ölçeği'nin Türkçe Uyarlaması: Geçerlik ve

Güvenirlik Çalışması]. *Journal of Theory and Practice in Education/Eğitimde Kuram ve Uygulama, 10*(2), 393-407.

Schwartz, R. S. (2004). *Epistemological views in authentic science practice: A cross-discipline comparison of scientists' views of nature of science and scientific inquiry*. Oregon State University, Corvallis, OR.

Timur, B.,& Kıncal, R. Y. (2010). İlköğretim 7. sınıf fen bilgisi dersinde sorgulamalı öğretimin (inquiry teaching) öğrenci başarısına etkisi. *Türk Eğitim Bilimleri Dergisi, 8*(1), 41-65.

Wu, H.-K.,& Krajcik J.S. (2006). Inscriptional practices in two inquiry-based classrooms: A case study of seventh graders' use of data tables and graphs. *Journal of Research in Science Teaching, 43*(1), 63–95.

Yılmaz, Z. & Karamustafaoğlu, S. (2015). Öğretmen adaylarının sorgulama becerilerinin farklı değişkenler açısından incelenmesi. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 25,* 347-363.

Appendix 1: The Turkish version of "The Views about Scientific Inquiry (VASI)" questionnaire

Bilimsel Sorgulama Hakkındaki Görüşler Anketi

1- Kuşlarla ilgilenen bir insan farklı türlerde besin yiyen yüzlerce farklı türdeki kuşu incelemiştir. Benzer türde besin yiyen kuşların gagalarının şeklinin de benzer olduğunu fark etmiştir. Örneğin, sert kabuklu fındık yiyen kuşlar kısa ve sert gagaya, böcek yiyen kuşlar ise uzun ve zayıf gagaya sahiptir. Bu kişi bir kuşun gaga şekliyle yediği besin türü arasında ilişki olup olmadığını merak etmiş ve bu soruya cevap bulmak için veri toplamaya başlamıştır. Kuşların gaga şekliyle yediği besin türü arasında bir ilişki olduğu sonucuna ulaşmıştır.

   a. Bu kişinin araştırmasının bilimsel olduğunu düşünüyor musunuz? Lütfen neden olduğunu / olmadığını açıklayınız.

   b. Bu kişinin araştırmasının bir deney olduğunu düşünüyor musunuz? Lütfen neden olduğunu / olmadığını açıklayınız.

   c. Bilimsel araştırmalarda birden fazla yöntem izlenebileceğini düşünüyor musunuz?

   - Hayırsa, lütfen neden bilimsel araştırmalarda tek bir yöntem izlenebileceğini açıklayınız.

   - Evetse, lütfen farklı yöntemler içeren iki araştırma tanımlayınız ve bu yöntemlerin nasıl farklılaştığını ve nasıl hala bilimsel olarak kabul edilebileceklerini açıklayınız.

2- İki öğrenciye bilimsel araştırmaların her zaman bir soruyla mı başlaması gerektiği sorulmuştur. Öğrencilerden biri "evet" derken diğeri "hayır" demiştir. Siz hangisine katılıyorsunuz ve neden? Bir örnek vererek açıklayınız.

3- a) Eğer bilim insanları aynı soruyu araştırıyor ve veri toplamak için aynı yöntemleri izliyorsa, hepsi aynı sonuçlara mı ulaşır? Neden olduğunu/olmadığını açıklayınız.

   b)Eğer bilim insanları aynı soruyu araştırıyor ve veri toplamak için farklı yöntemleri izliyorsa, hepsi aynı sonuçlara mı ulaşır? Neden olduğunu/olmadığını açıklayınız.

4- Lütfen "veri" ve "delil"in birbirinden farklı olup olmadığını açıklayınız. Bir örnek veriniz.

5- Bir gün bilim insanlarından oluşan iki takım laboratuvarlarına doğru yürürken lastiği patlamış bir arabanın kenara çektiğini görürler. İki takımda "Bazı markaların lastikleri patlamaya daha mı yatkındır?" diye sorar.

   - A takımı laboratuvara geri dönmüş ve birçok değişik lastiğin performansını üç farklı yol yüzeyinde test etmiştir.

   - B takımı laboratuvara geri dönmüş ve bir marka lastiği üç farklı yol yüzeyinde test etmiştir.

Bir takımın diğerinin izlediği yoldan neden daha iyi olduğunu açıklayınız.

Her gün alınan ışığın dakikası	Bir haftalık bitki büyümesi (cm)
0	25
5	20
10	15
15	5
20	10
25	0

6- Aşağıdaki tabloda gösterilen veriler, bir hafta içinde bitki büyümesi ve her gün alınan ışığın dakika sayısı arasındaki ilişkiyi göstermektedir.

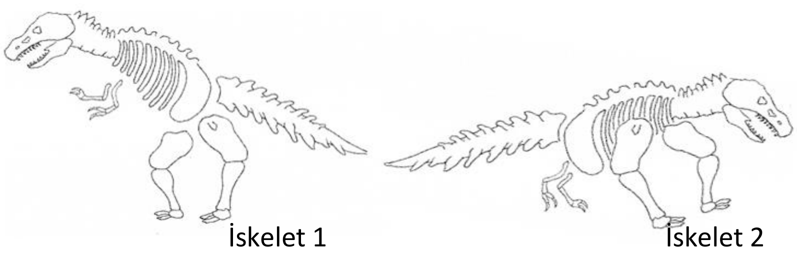
Bu verilere göre, aşağıdaki sonuçlardan birini seçiniz ve hangisine katıldığınızı açıklayınız.

- ☐ *Bitkiler daha fazla güneş ışığı ile daha uzun büyürler.*
- ☐ *Bitkiler daha az güneş ışığı ile daha uzun büyürler.*
- ☐ *Bitkilerin büyümesinin güneş ışığı ile bir ilgisi yoktur.*

a. Neden bu sonucu tercih ettiniz?

b. Veriler beklediğiniz gibi mi? Neden evet/hayır?

7- Bir grup bilim insanı bir dinozorun fosilleşmiş kemiklerini bulmuştur. Bu bilim insanları kemikleri iki olası düzenlemeyle birleştirmiştir.



a. Bu düzenlemelerden neden çoğu bilim insanının kemiklerin yerleştirilmesinde *1 nolu* iskeletin en iyi olduğuna karar vereceği yönündeki görüşünüzü en az iki sebeple açıklayınız.

b. Yukarıdaki soruya verdiğiniz cevap düşünüldüğünde, bilim insanları kendi sonuçlarını açıklarken ne tür bilgiler kullanırlar?

c. Bilim insanları herhangi bir araştırma sırasında, kendi sonuçlarını açıklarken ne tür bilgiler kullanırlar?